

Simulation of Type-II Quantum Well Photodetectors

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Applicable Models and Features

Input command looping technique to set up 150 pairs of coupled type-II MQW.

Type-II MQW optical gain/absorption spectrum from complex-MQW optical gain model.

Design of absorption spectrum by adjusting type-II band alignments.

Non-local tunnelling junction model based on quantum mechanical calculation.



Tutorial example

* Structure similar to

R. Sidhu, N. Duan, J. C. Campbell,
and A. L. Holmes, Jr.,

"A 2.3 μ m CUTOFF WAVELENGTH
PHOTODIODE ON InP USING
LATTICE-MATCHED GaInAs-
GaAsSb TYPE-II QUANTUM
WELLS,"

2005 International Conference on
Indium Phosphide and Related
Materials,

p. 148, 2005.

* Key adjustable parameters: band-
offset, non-local tunnelling junction
transport mean-free-path and
mobility parameter(s).

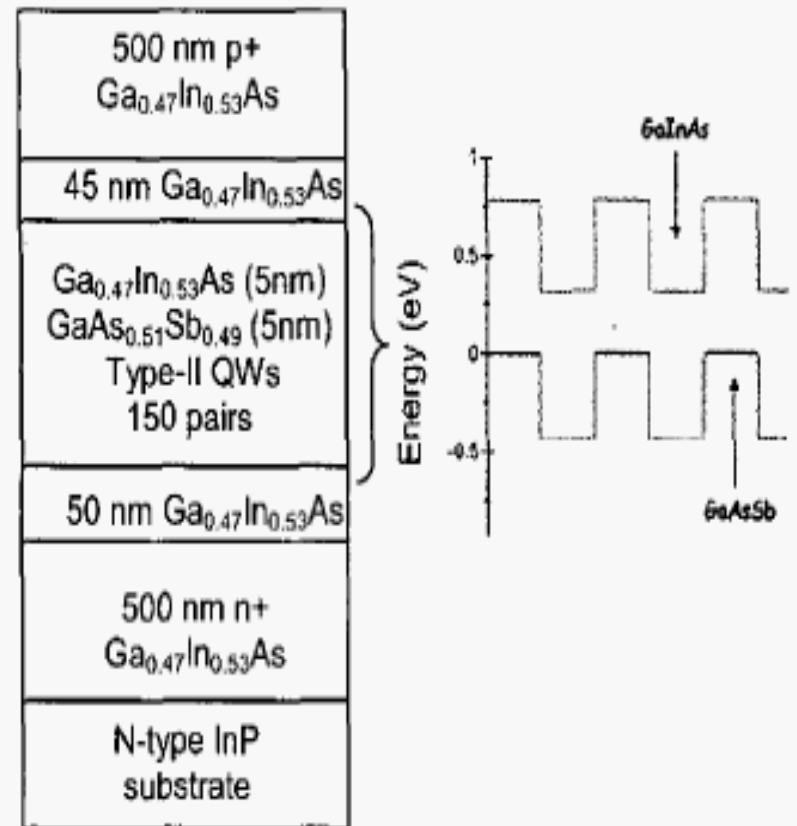
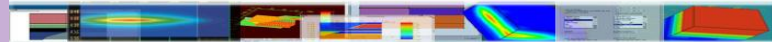
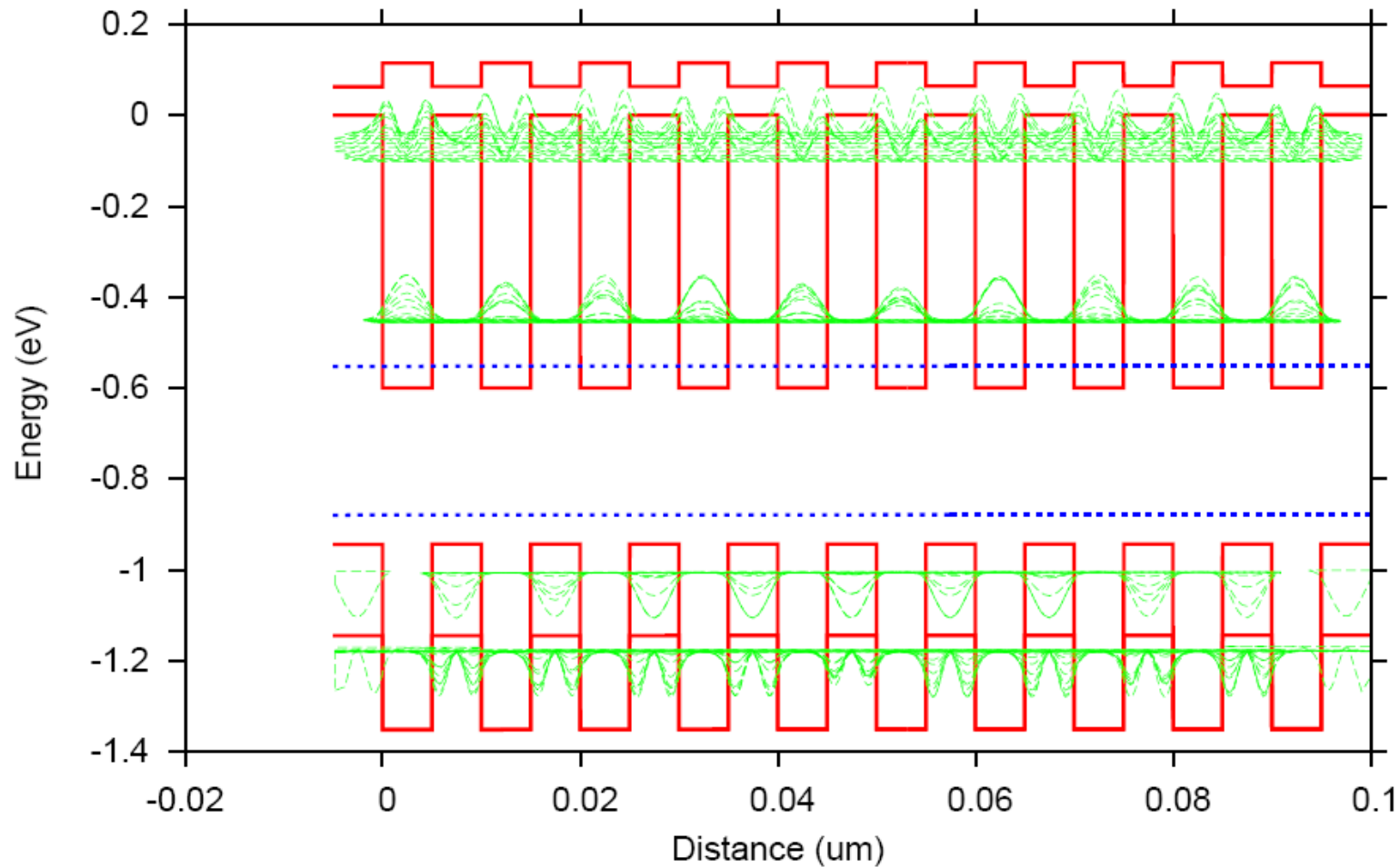
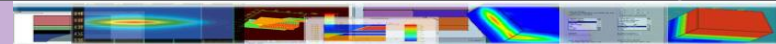
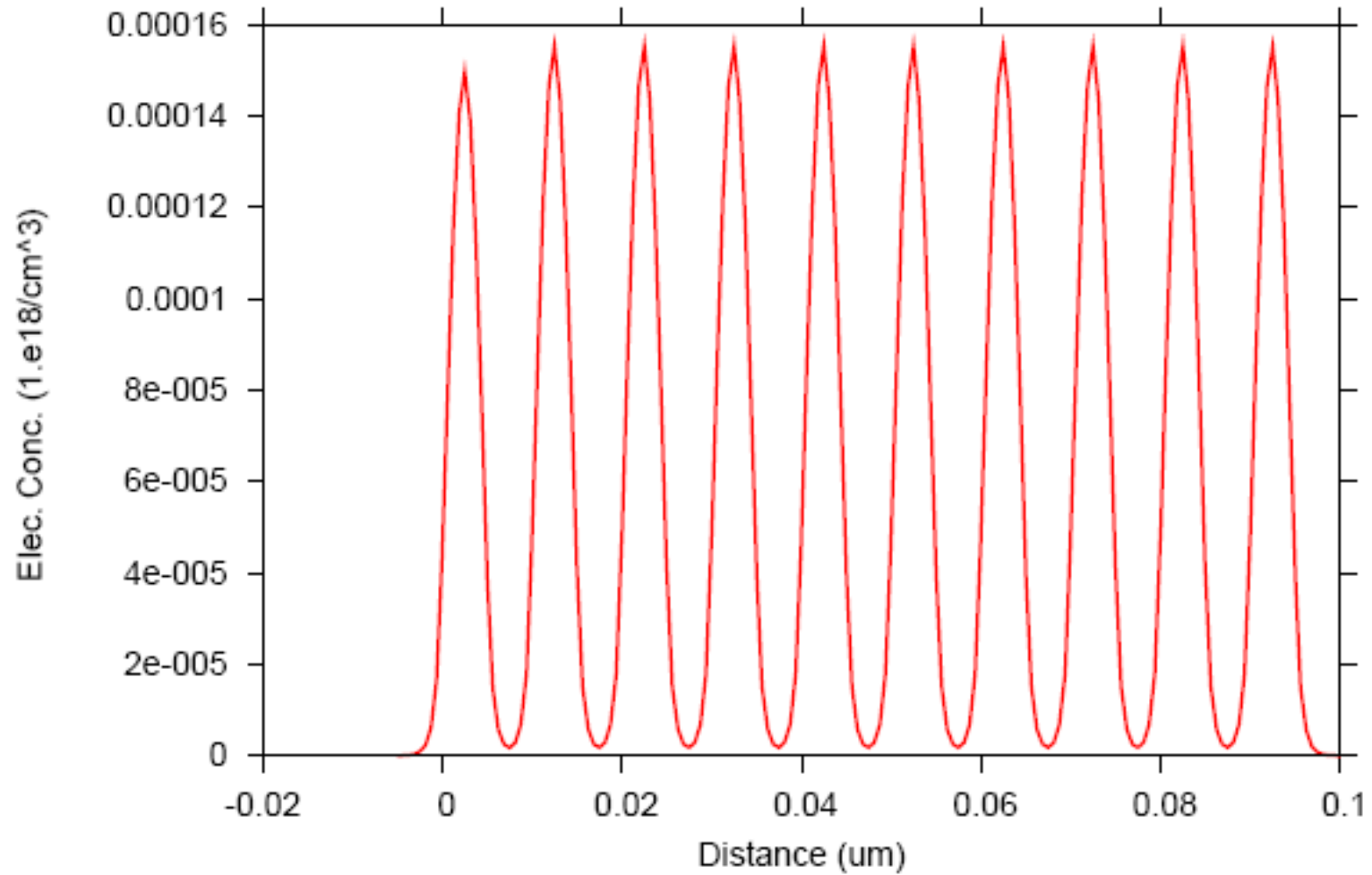


Figure 1. Schematic device structure and band lineup between GaInAs-GaAsSb

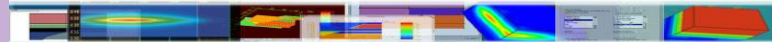
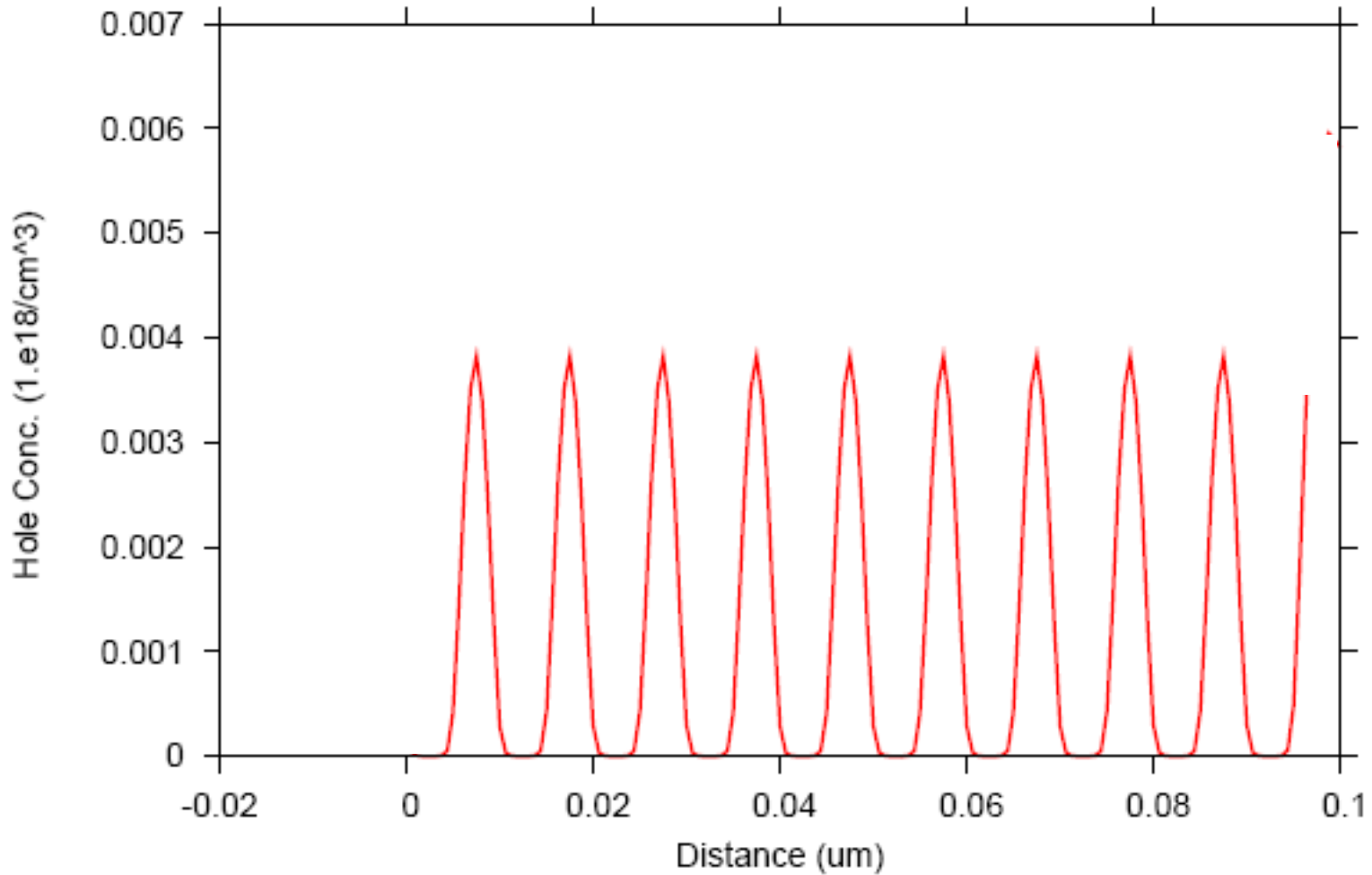
Type-II QWPD: band structure design



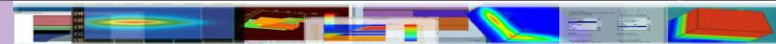
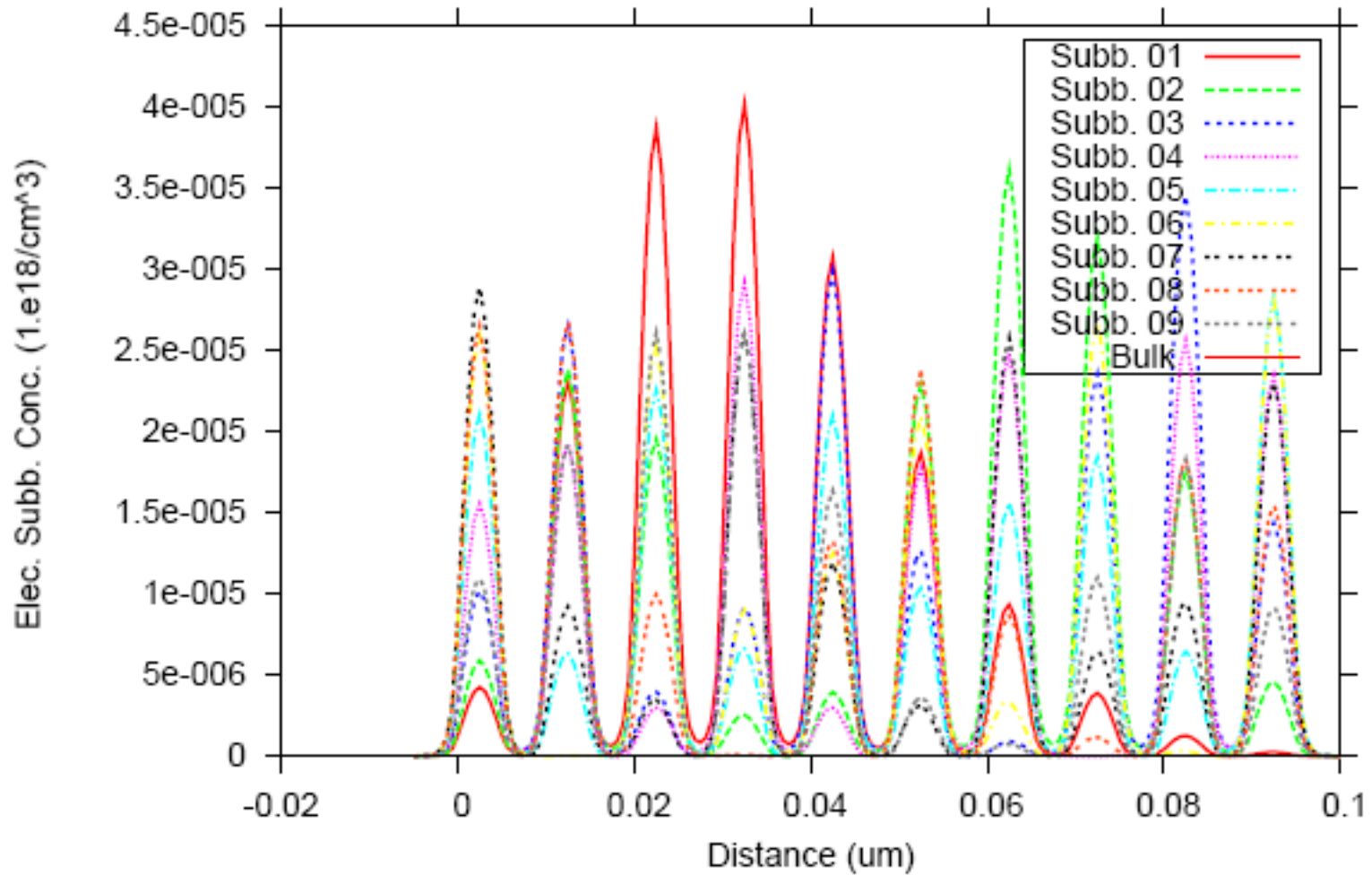
Type-II QWPD: electron densities



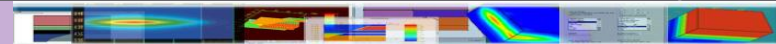
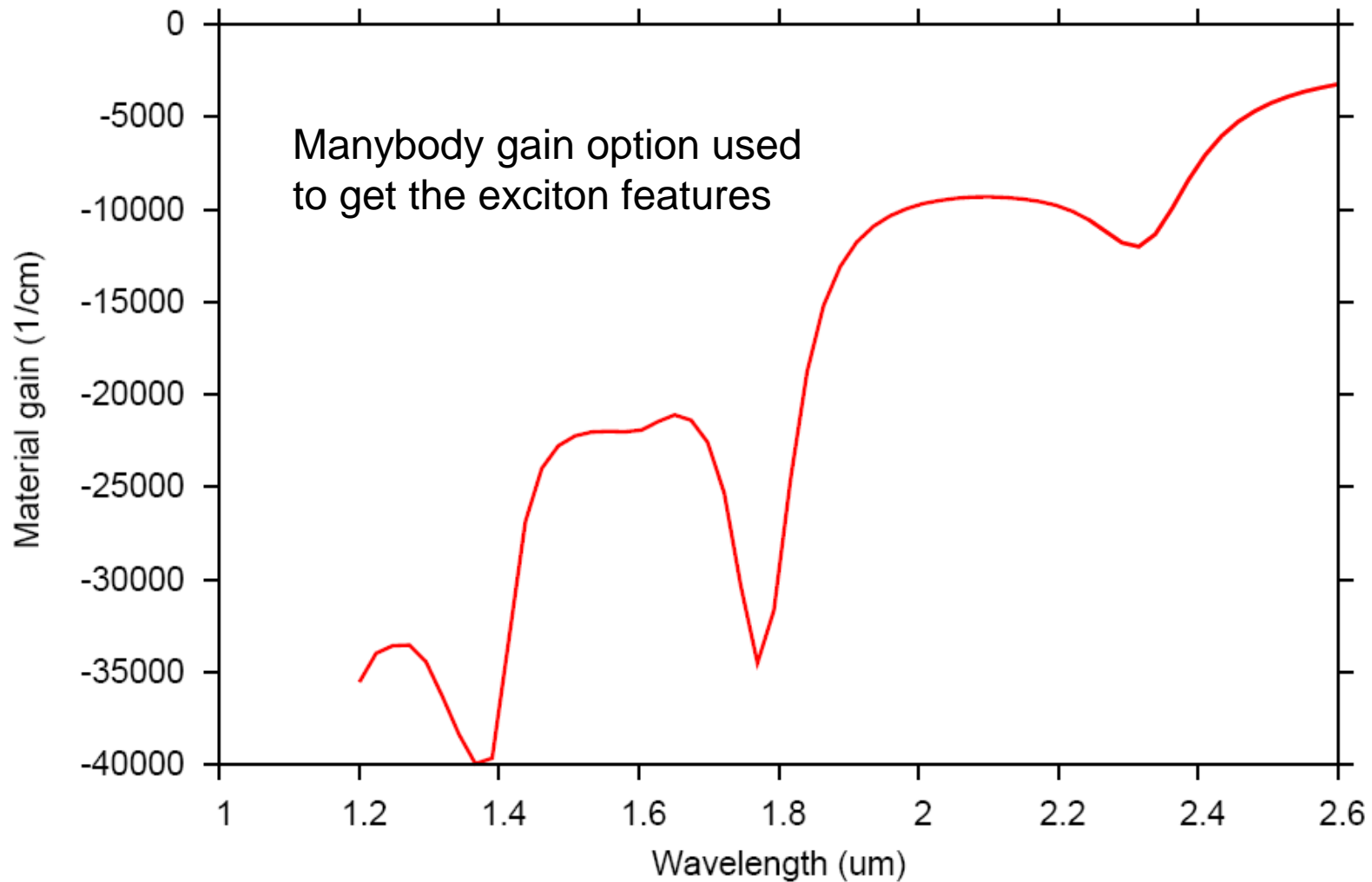
Type-II QWPD: hole densities



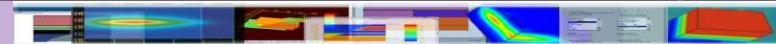
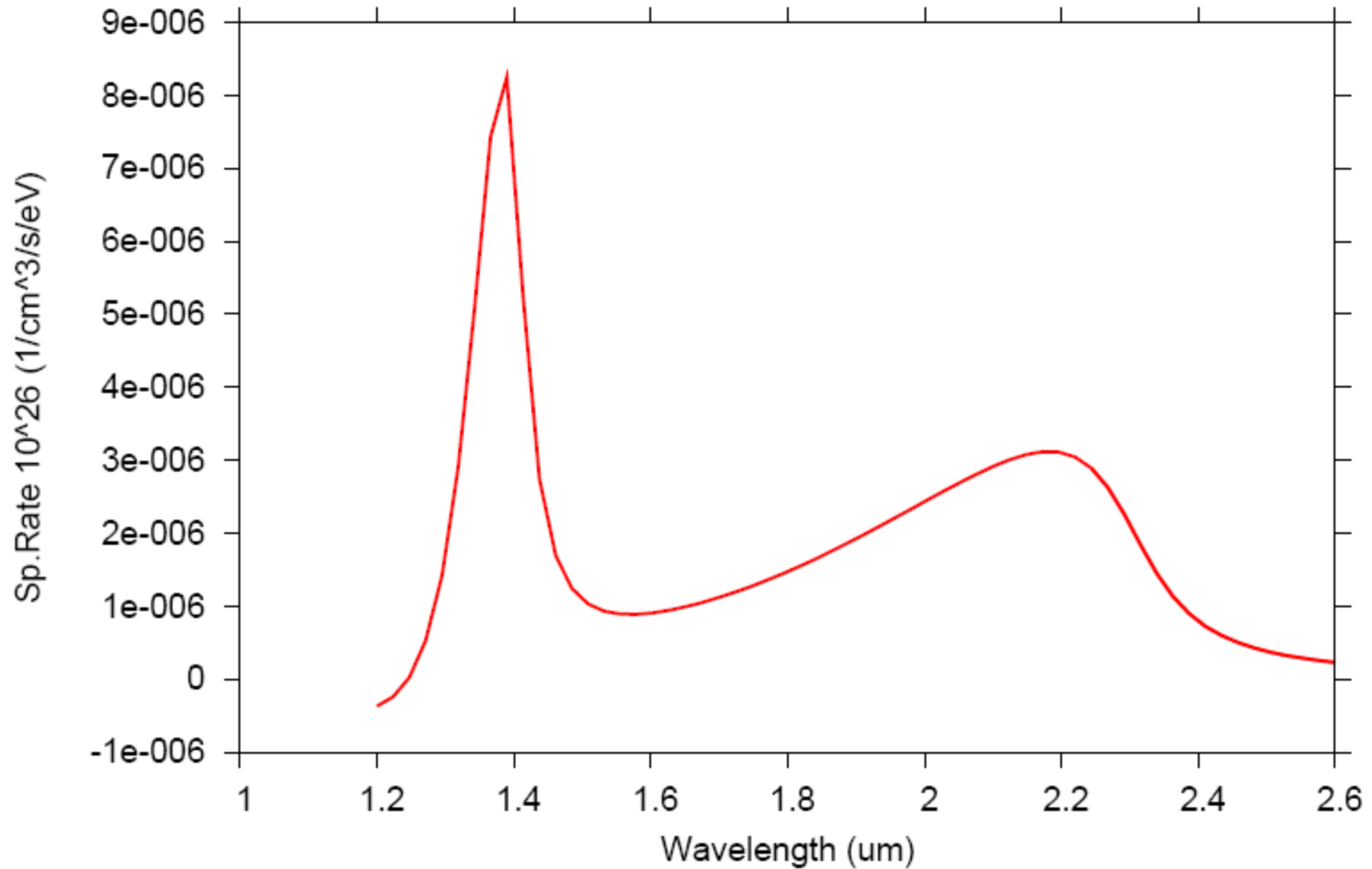
Type-II QWPD: electron subbands



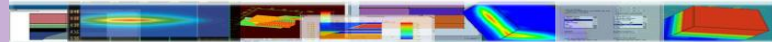
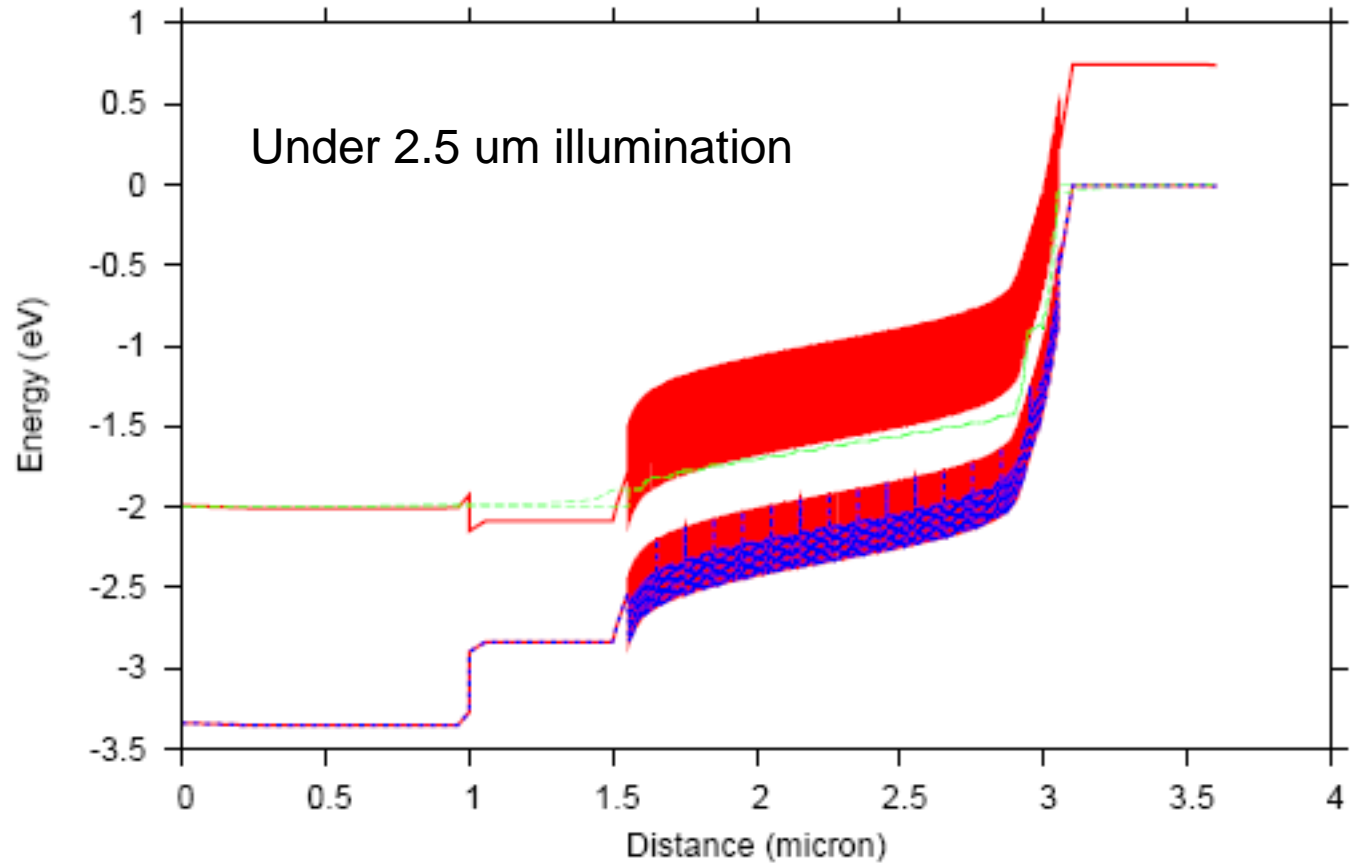
Type-II QWPD: optical gain or -absorption



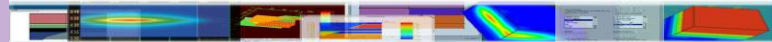
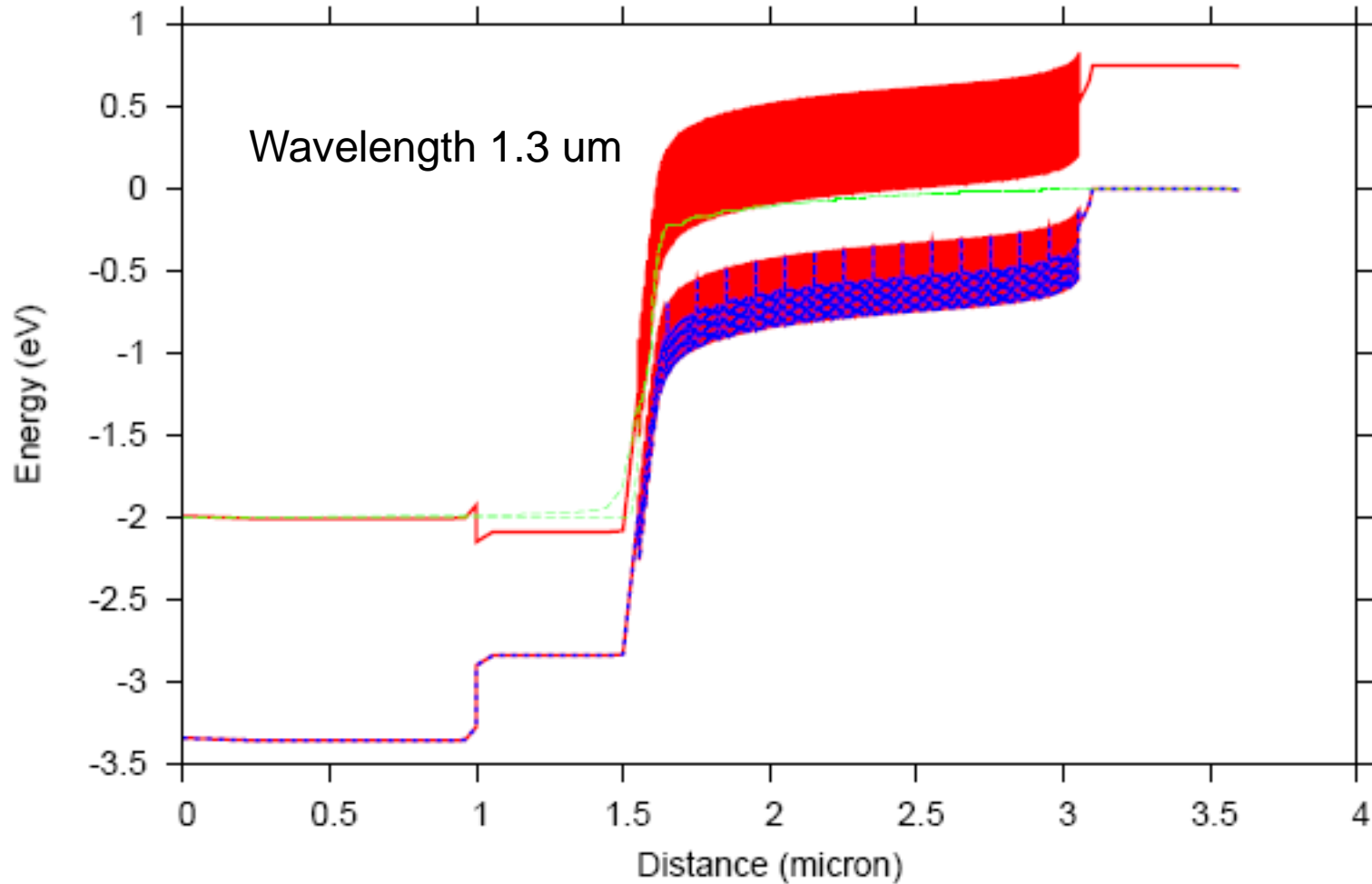
Type-II QWPD: spontaneous emission



Type-II QWPD: band diagram at 2 Volt



Type-II QWPD: band diagram at 2 Volt



Type-II QWPD: dark current

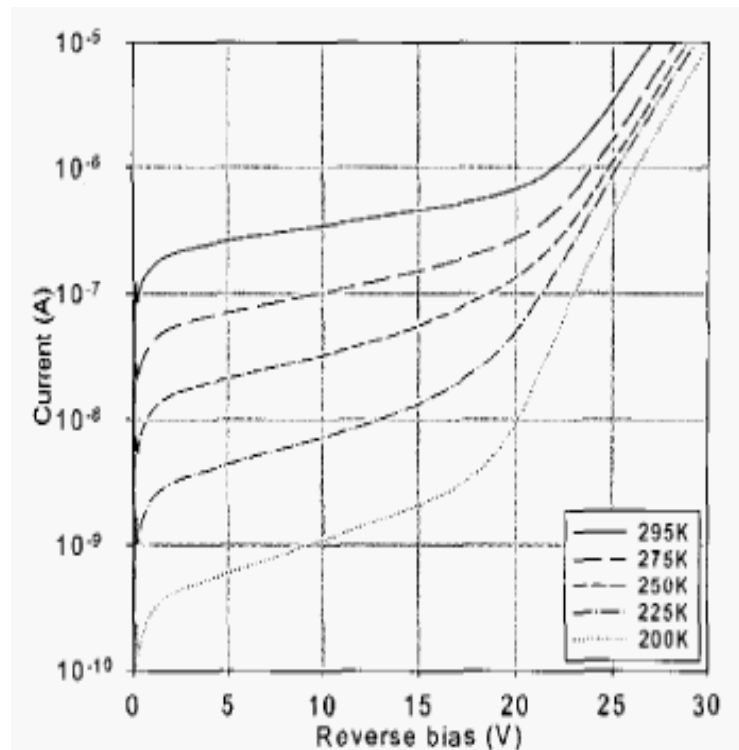
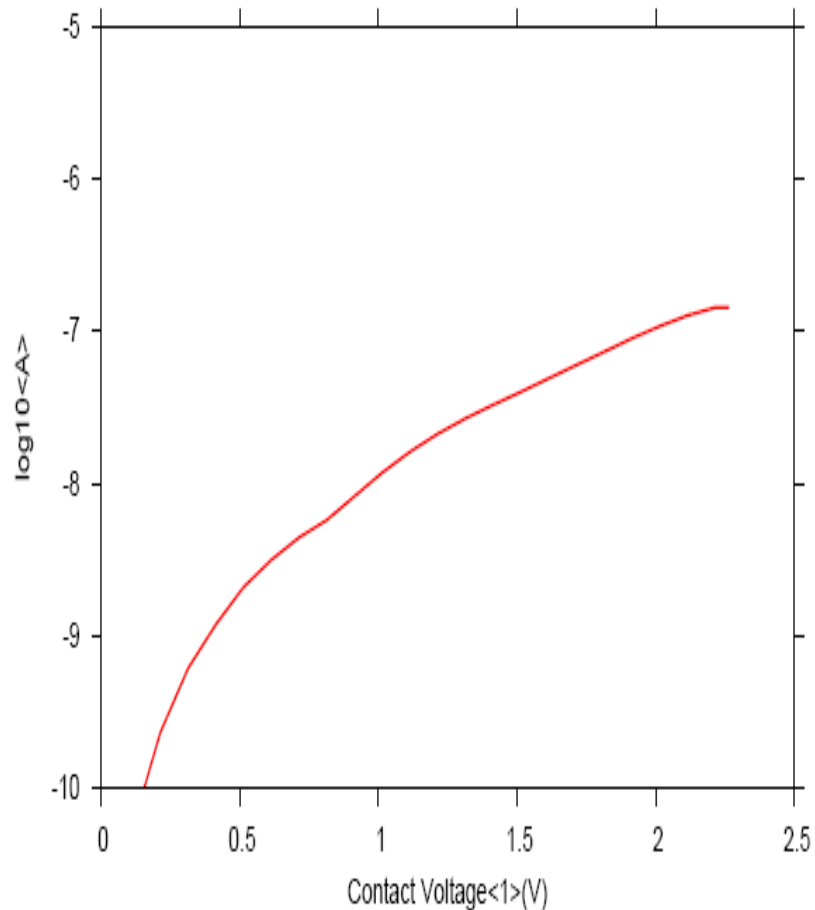
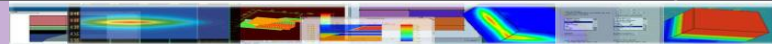
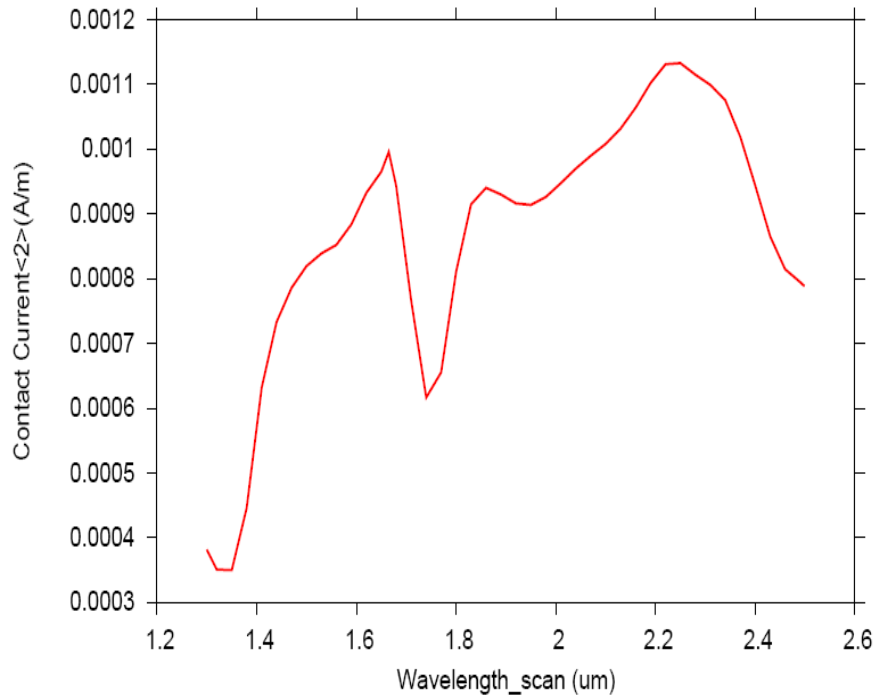


Figure 2. Dark current vs. voltage from a 64 μm diameter device, measured at 200K, 225K, 250K, 275K, and 295K.



Type-II QWPD: current response



Width=1um

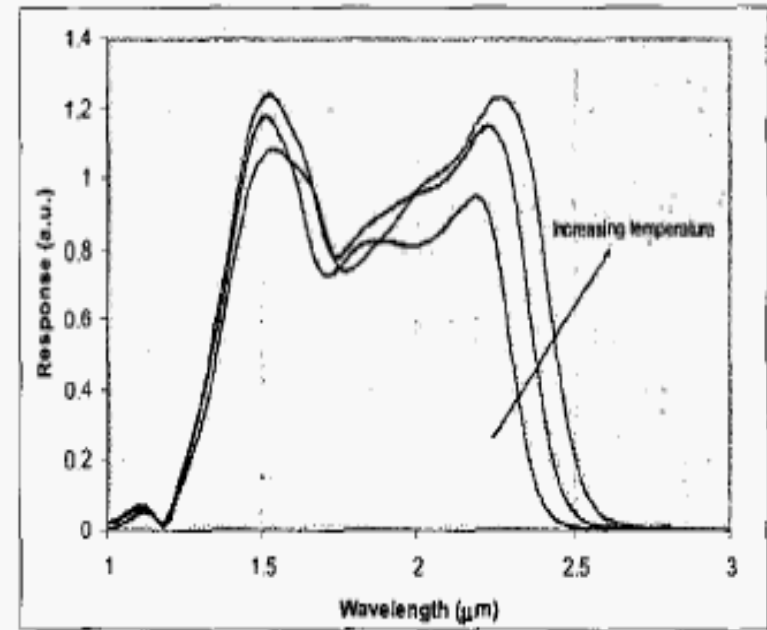
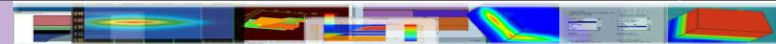


Figure 3. Normal incidence photoresponse at 200K, 250K, and 295K, measured at -2V bias.



Type-II QWPD: external efficiency

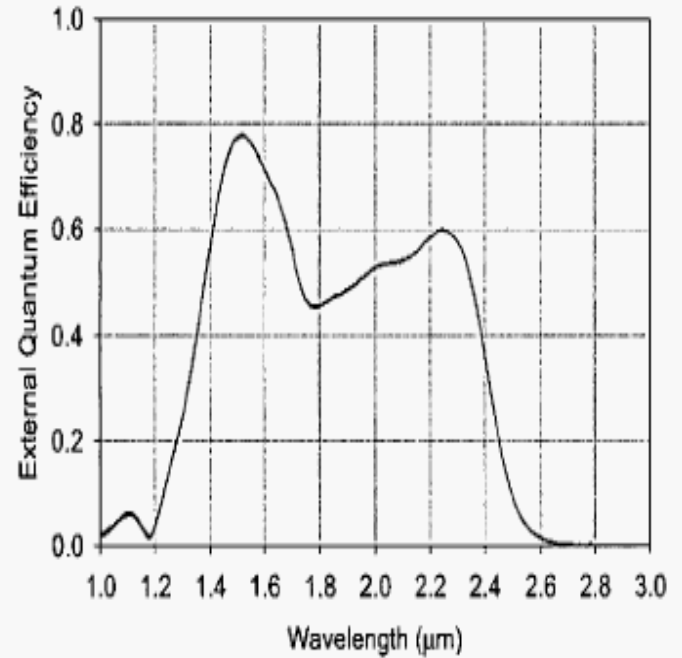
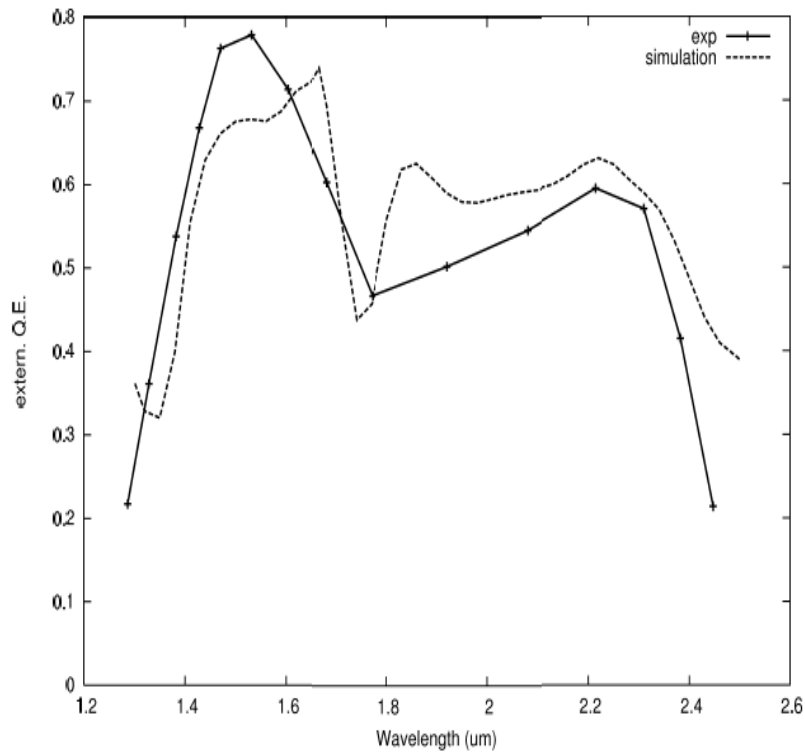
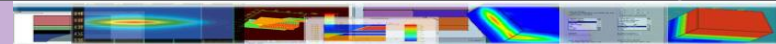
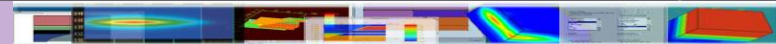
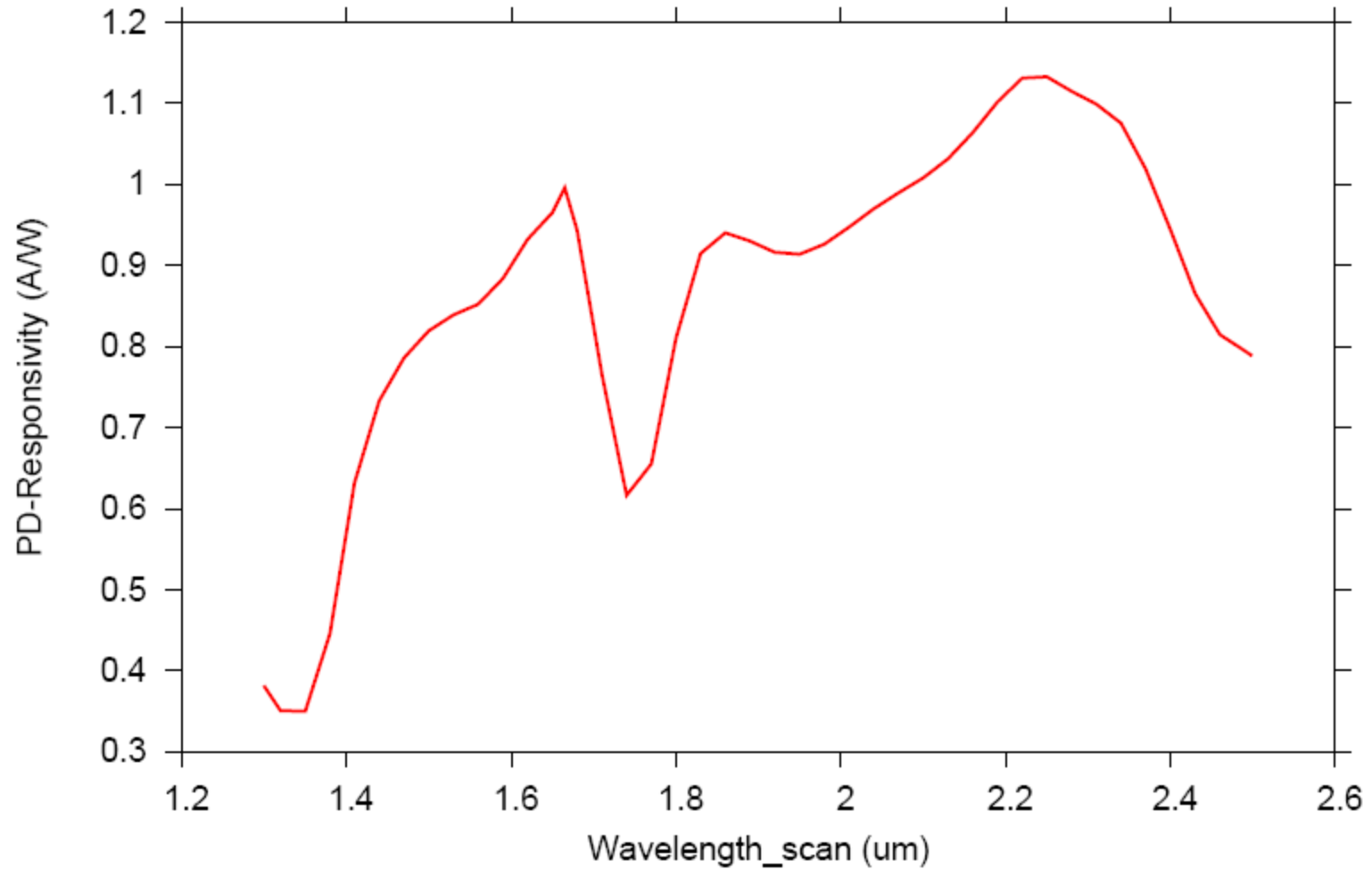


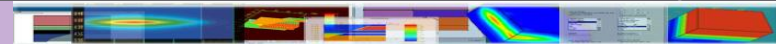
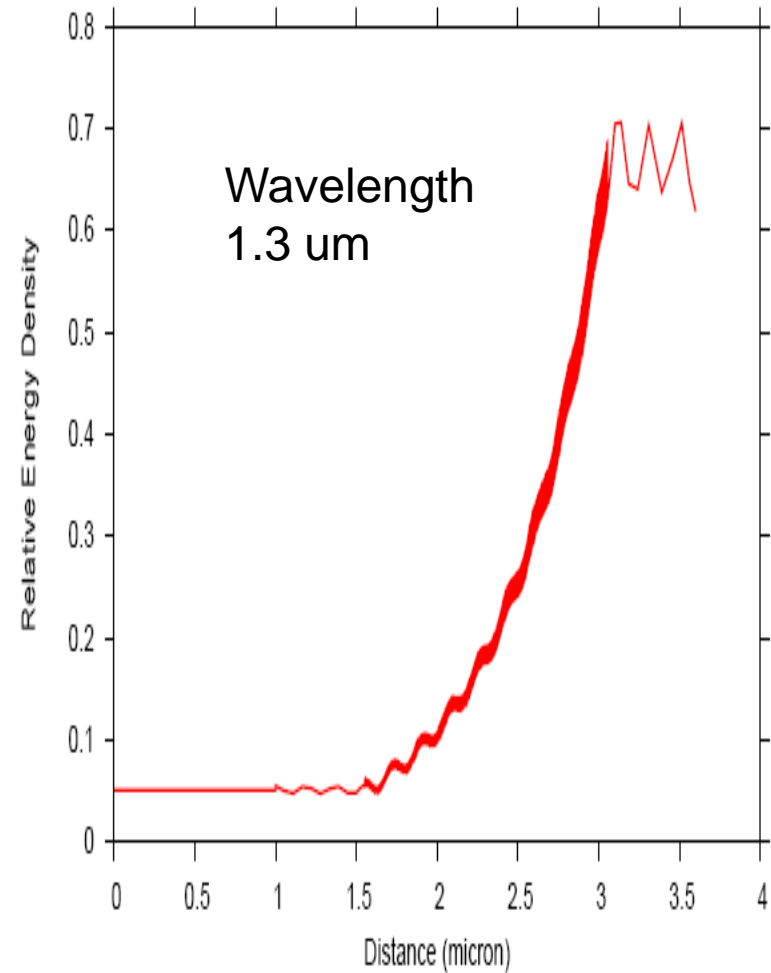
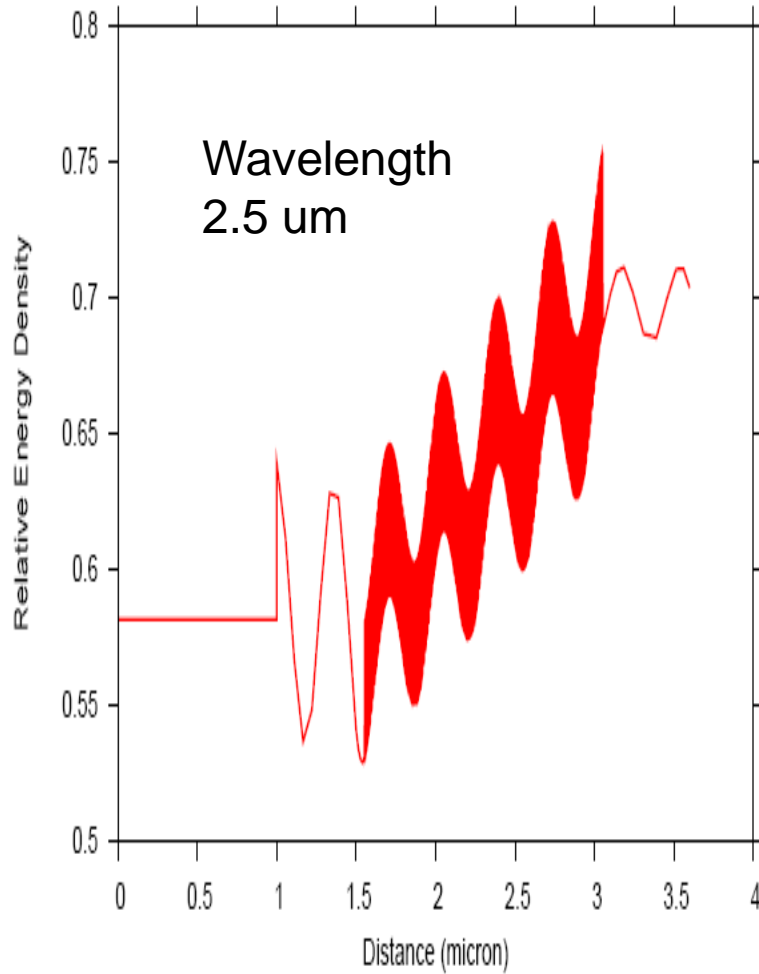
Figure 5. Room temperature external quantum efficiency vs. wavelength, at -2V bias



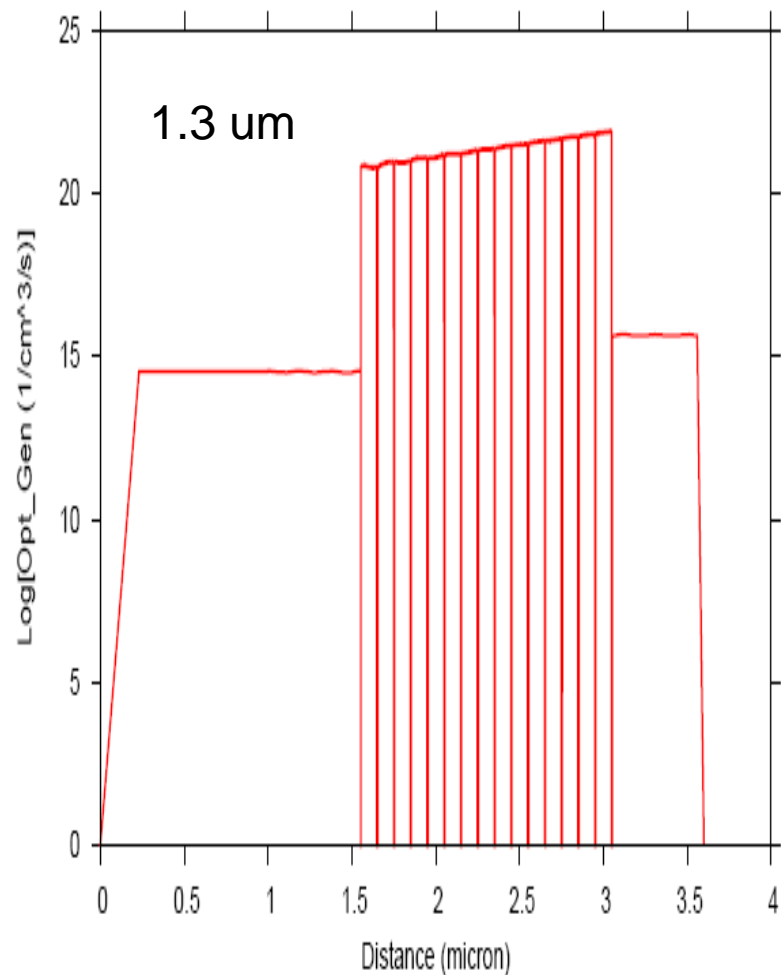
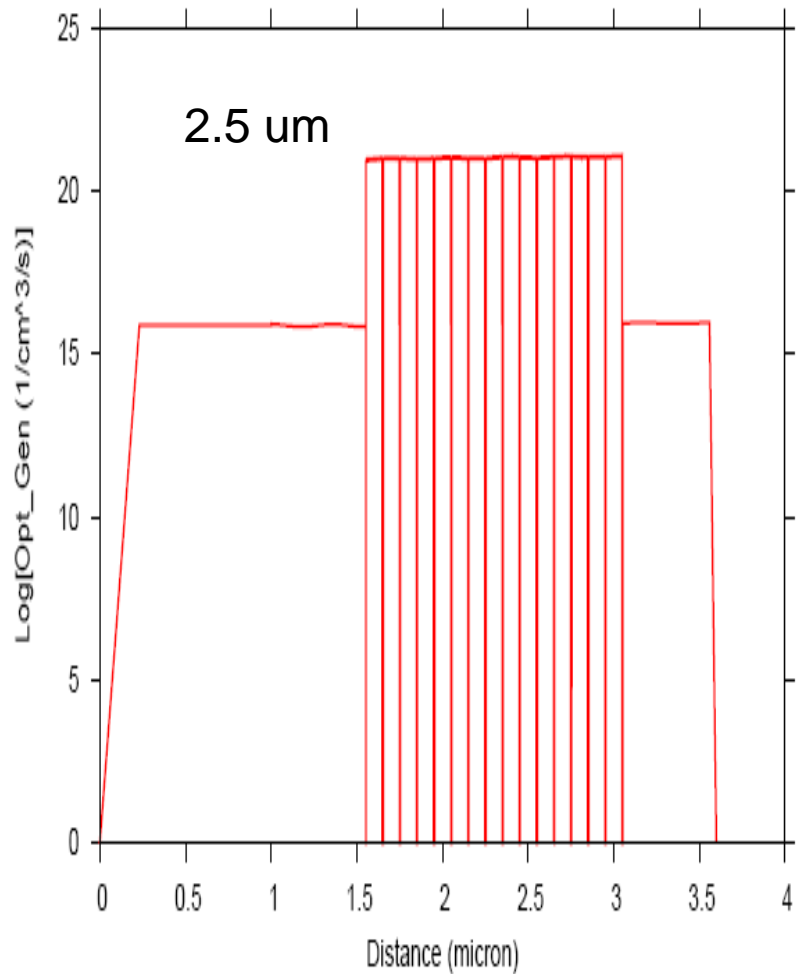
Type-II QWPD: responsivity



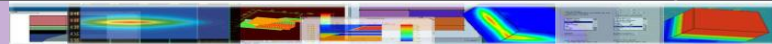
Type-II QWPD: light intensity profiles



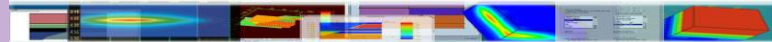
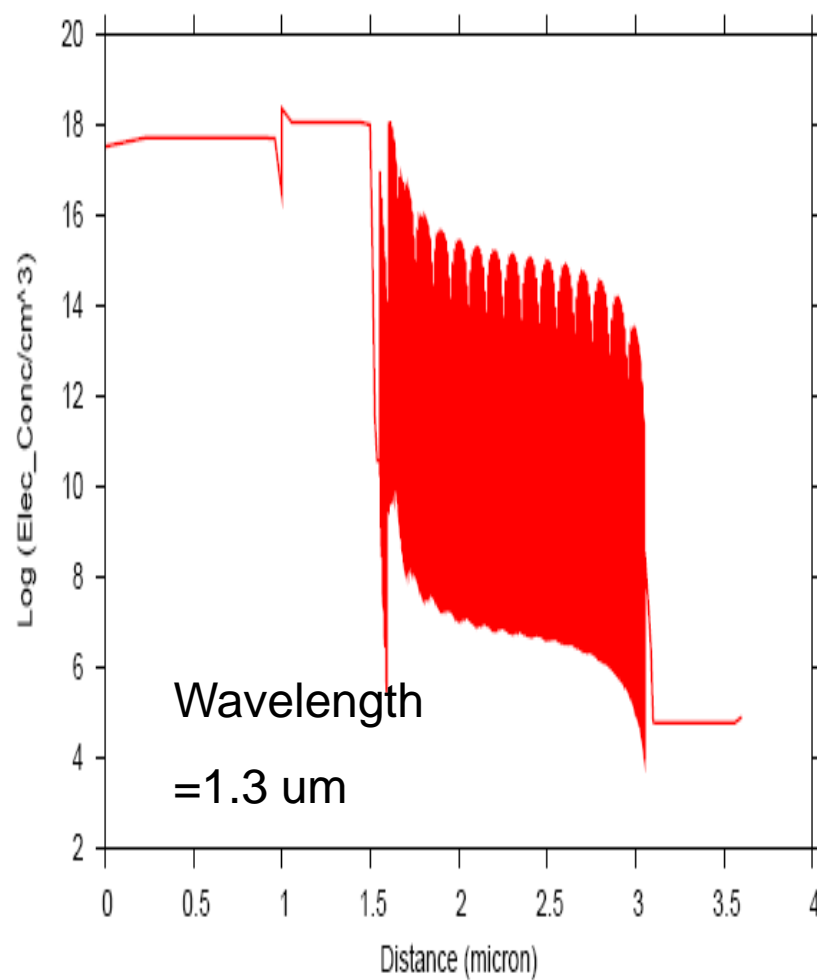
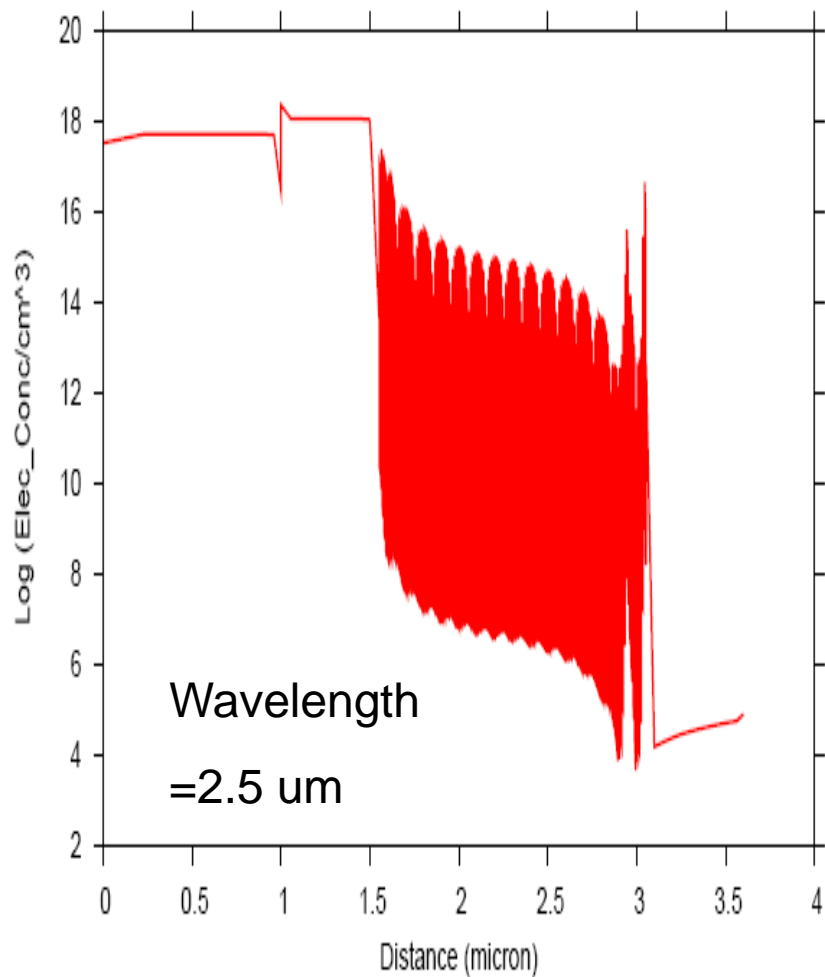
Type-II QWPD: optical generation



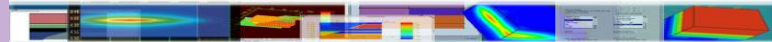
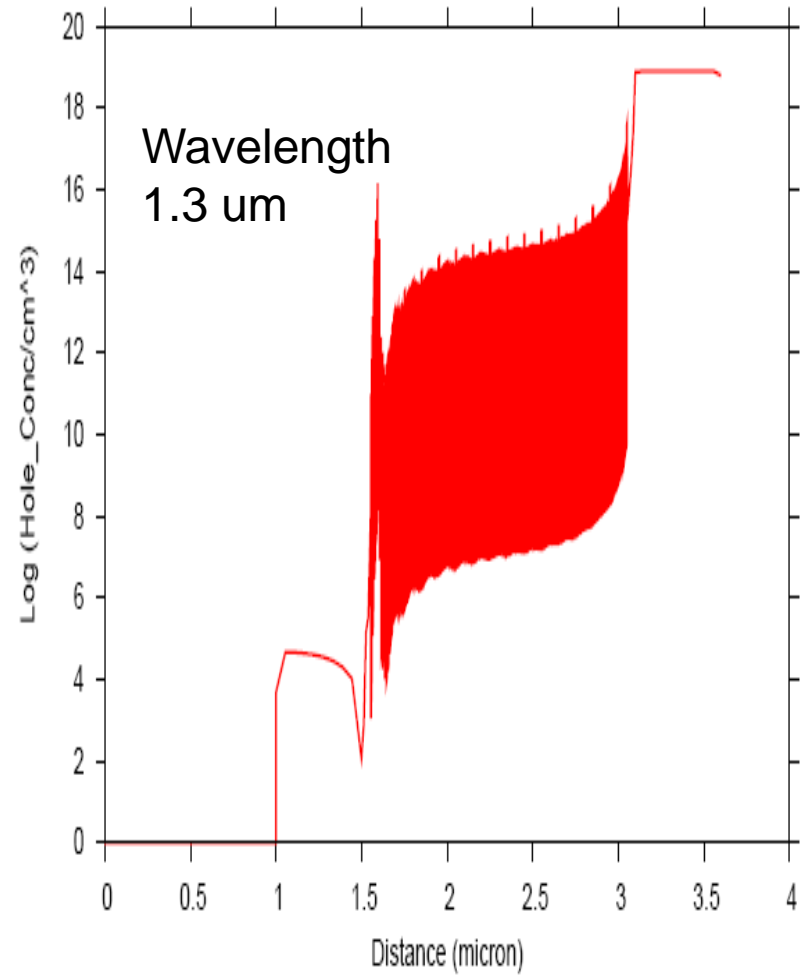
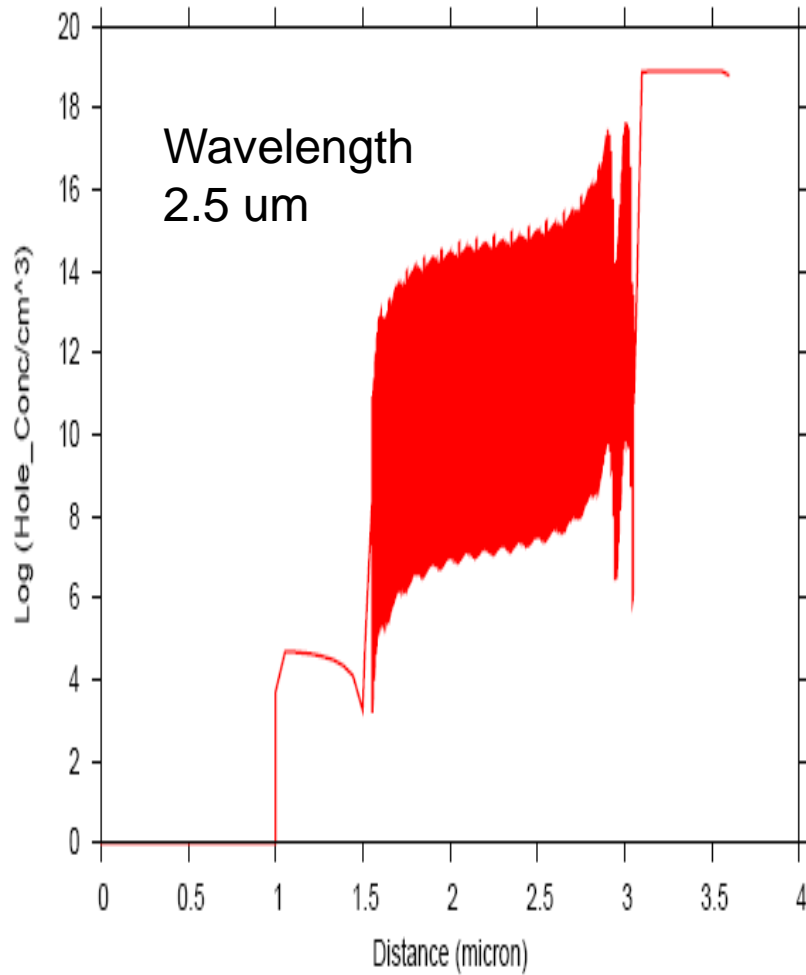
MQW div. into 15 blocks



Type-II QWPD: electron concentration



Type-II QWPD: hole concentration



Discussions

PD response as a function of wavelength depends on 3 factors:

- (1) Intrinsic material absorption spectrum ;
- (2) amount and location of absorption for different wavelengths;
- (3) how non-local tunnelling junction current is activated by optical generation.

Dark current originated from spontaneous recombination which dominates the tunnelling current at dark.

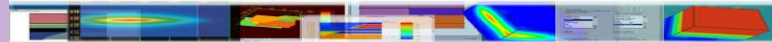


Summary

Crosslight software ready with

- (1) Accurate computation of minibands of type-II MQW.
- (2) Prediction of material optical absorption spectrum and spontaneous recombination rate as a cause of dark current.
- (3) Non-local transport of tunnelling current based on quantum mechanical calculation taking into account local optical generation rates.

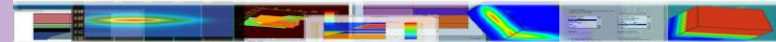
Crosslight model demonstrated through a typical type-II MQW PD with results consistent with experimental measurements.



A Glimpse

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